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GEOLOGY.—*A recent collection of late Pliocene invertebrates from the head-waters of the Amazon.*¹ JULIA GARDNER, U. S. Geological Survey.

Through the courtesy of Dr. Joseph T. Singewald, Jr., a collection of late Tertiary fossil invertebrates, chiefly Mollusca, made from deposits along the Peruvian head-waters of the Amazon during the field season of 1925, has been sent to the U. S. Geological Survey for examination. More than fifty years ago, in December, 1867, a similar fauna was collected at Pebas, in the same region, by James Orton, at that time the head of the Department of Geology at Vassar College. Professor Orton spent only a few hours at Pebas, but later and more extensive collections were made by Mr. Hauxwell, a naturalist of long residence in the Amazon Valley. Field observations were also made by Dr. Charles Frederick Hartt, who first went to Brazil as a member of Agassiz's staff on the Thayer expedition and later was appointed chief of Dom Pedro's Geological Commission. The Mollusca collected during these early explorations were distributed internationally and reports were made in scientific journals of the United States, England, and Austria and, very much later, of Brazil. The fauna was involved in questions of unusual interest—the age; the nature of the environment, whether dominantly fresh water, brackish, or marine; and the bearing of the deposits upon Agassiz's theory, later discarded, of the glacial origin of the Amazon valley. Gabb² considered the fauna "marine or perhaps rather a brackish water fauna" but did not commit himself upon the age further than the observation

¹ Received November 3, 1927.

² W. M. GABB, *Descriptions of fossils from the clay deposits of the Upper Amazon*. Am. Journ. Conch. 4: 197-200. pl. 16, f. 1-6. 1869.

that the retention of the color markings of *Neritina* "would point to a very recent era." Conrad³ believed the age "not later than Tertiary" and the biota either fresh or brackish but certainly not marine. He also observed that the condition of preservation of the double valves precluded the possibility of transportation for any distance from the spot in which the animal lived and died. Woodward⁴ did not greatly concern himself with the age further than assigning the fauna to the Tertiary, but he refuted Agassiz's theory of the glacial origin of the deposits both by his own observations and by a communication from Professor Orton to the effect that "the perfect preservation of the most delicate parts, some specimens retaining even the epidermis, shows a quiet lake or estuary," and "that there certainly are no indications of a grinding glacier." Woodward was convinced of the estuarine ecology of the fauna and believed that the raised beaches observed by Darwin near the mouth of the Rio Plata and packed with *Azara labiata* d'Orbigny furnish an almost perfect analogy. Boettger⁵ thought the Pebas deposits represented the old delta of the Marañon, and that in the depth and extent of the old delta we have a geologic chronometer. He concluded that the Pebas was an interior fauna living at the mouth of the Marañon during Oligocene or possibly even Eocene times. He further observed that the extreme variability of the few but abundant species is characteristic of all interior faunas. Barrington Brown,⁶ while engaged in geological work for the Amazon Steam Navigation Company, traced the Pebas beds as far down as São Paulo, 150 miles below the Peruvian boundary and more than double that number below Pebas. He found them, too, 50 miles up from the mouth of the Javary, the stream entering the Marañon, as the Amazon is commonly known in that area, from the south and west and forming the boundary line between Peru and Brazil. He gave several sections, all of them indicating more or less clearly an interfingering series of blue clays and lignites, the clays commonly fossiliferous, the clay-lignite series overlain commonly to a considerable thickness by a mottled grey and red clay, the "Drift" of Agassiz. The fauna, collected at Canama, on the Javary, was studied by

³ T. A. CONRAD, *Descriptions of new fossil shells of the Upper Amazon*. Am. Journ. Conch. 6: 192-198. pl. 10, 11; f. 1, 7, 8. 1871.

⁴ HENRY WOODWARD, *The Tertiary shells of the Amazon Valley*. Ann. Mag. Nat. Hist. (4) 7: 59-64; 101-109. 1871.

⁵ OSKAR BOETTGER, *Die Tertiärfauna von Pebas am oberen Marañon*. Kais.-kön. geol. Reichsanst., Jahrb. 28: 485-504. pl. 13-14. 1878.

⁶ C. BARRINGTON BROWN, *On the Tertiary deposits on the Solimões and Javary Rivers in Brazil*. Quart. Journ. Geol. Soc. London 35: 76-81. 1879.

Etheridge,⁷ who considered it Tertiary, fresh water, estuarine, possibly in part marine, and inferred from it a westward extension of the sea 1500 to 2000 miles west of the present debouchure of the Amazon. The *Chara* seeds common in the lignite are apparently referable to a genus widely distributed in stagnant, fresh, and brackish water. The excellent state of preservation of the wood, some of it only slightly altered, and the occasional coating of the woody parts of the surfaces with iron pyrites was noted by Barrington Brown. Interest in the Pebas fauna lapsed after 1879, but has been recently revived because of the economic possibilities, both in lignite and in the possible occurrence of petroleum. In 1924, De Oliveira Roxo⁸ reprinted the figures and much of the text of the papers by Gabb, Etheridge, and Woodward and described two new species, one a *Planorbis*, the other assigned to *Pupura*, a marine genus. The figure is not convincing, however, and too much weight should not be given to the determination. He doubtless reflected, however, the consensus of later opinion when he deduced a comparatively late age for the fauna, the upper Pliocene.

The Singewald collections were made at the classic Pebas locality and from a number of other outcrops on the Marañon and Napo Rivers from which the series had not been previously reported. This gives a possible area of outcrop extending from above Iquitos, Peru, to São Paulo, Brazil, some 400 to 500 miles along the Marañon; some 50 miles up the Napo, which enters the Marañon from the north; and an almost equal distance up the Javary, which enters it from the south. The series of fine grained clays and lignites through which the Marañon cuts its channel from Iquitos to São Paulo is apparently similar to that reported along the front of the Andes from Peru, through Bolivia and well down into the Argentine.

Both the sediments and the state of preservation of the fauna—especially the common occurrence of the locked double valves of *Anisothyris*—indicate deposition in very quiet water. In some of the deposits there was not only no rapid movement but not even sufficient circulation to carry off the decaying animal matter, and the shale and its contained fauna present the characteristic features of the "black

⁷ R. ETHERIDGE, *Notes on the Mollusca collected by C. Barrington Brown, Esq., from the Tertiary deposits of Solimões and Javary Rivers, Brazil*. Quart. Journ. Geol. Soc. London 35: 82-88. pl. 7. 1879.

⁸ M. G. DE OLIVEIRA ROXO, *Contribuição a paleontologia do Valle do Amazonas*. Serv. Geol. Min. Brasil, Bol. 11: 1-52. 1924.

shale" described by Goldman⁹—a blue black shale heavily impregnated with iron pyrites and carrying a few but very abundant depauperate species. Such deposits are particularly characteristic of the mouths of rivers, where precipitation of suspended matter is suddenly accelerated not only by the loss of current velocity but also by the additional deposition induced by the salt water, particularly the flocculation of the organic matter.

The entire Pebas fauna includes less than a score of species, most of them adaptable to either fresh or brackish water. One member of the *Potamides* group, described under the name *Cerithium coronatum* Etheridge, is not known to penetrate the upper courses of the rivers. Abundant small gastropods are referable to a group which favors the river just above the mouth. *Cypris* sp., the common fresh water ostracod, is present in considerable numbers. The most abundant and by far the most characteristic group, *Anisothyris*, a non-marine bivalve related to *Corbula*, has not been recognized in the Recent waters but finds a close analogue in *Azara labiata* d'Orbigny, abundant at the mouth of the Rio de la Plata. Darwin observed this species not only near Montevideo but also near San Pedro on the Parana, about 100 miles in an air line above Buenos Aires, where he noted vast numbers of *Azara labiata* packing the loose sands some 100 feet above the river bed. Mingled with the *Azara* of Montevideo, however, are numerous littoral species of which there is no trace in the Pebas fauna. Though the greater number of the Pebas species suggest the proximity of salt water, it does not seem probable that the Atlantic Ocean washed the foothills of the Andes so late as the Upper Pliocene. Even today the Amazon River suggests a series of inland lakes and this was probably true in the late Tertiary not only of the Amazon drainage but also of rivers to the south. The Andean streams must already have spread wide deltas, for the sediments are all fine. Across such flood plains the rivers wandered, leaving bayous and ox bows which perhaps became increasingly saline. The freest movement of the Pebas fauna seems to have been to the south, since there is probably a genetic relationship between two groups so unique and so strongly characterized as *Azara* and *Anisothyris*. Both *Anisothyris* and *Azara* are much restricted in their distribution. *Anisothyris* is characteristic of the head-waters of the Amazon, *Azara* of the lower La Plata. *Azara* is sparsely represented in Rio Grande do Sul but no trace of it has

⁹ M. I. GOLDMAN, "Black shale" formation in and about Chesapeake Bay. Bull. Am. Assoc. Petr. Geol. 8: 195-201. 1924.

been recorded from the lower Amazon. The line of communication between the late Pliocene *Anisothyris* and the recent *Azara* was probably over the even now ill-defined divide between the upper Amazon and the La Plata. The close relationship between the fossil Mollusca of the head-waters of the Amazon and those now living in the lower La Plata is brought out much more emphatically by the fresh-water mussels of the Pebas fauna, which are now under investigation by William B. Marshall, Assistant Curator of the U. S. National Museum.

The loosely organized drainage of the Upper La Plata and the Upper Amazon seems a more plausible explanation of the existing faunal relationships than the later erection of a barrier between the Upper and Lower Amazon. In any case there is little trace of any recent lineage of the late Tertiary Pebas faunas in the lower waters of the Amazon.

BOTANY.—*Ruellia tuberosa and a few of its close relatives.*¹ EMERY C. LEONARD, National Museum. (Communicated by WILLIAM R. MAXON).

Every monographer, no doubt, is familiar with the fact that in most of his special groups there will be found a species more troublesome and puzzling than any of the others, a species with an extensive range, with numerous variations, and, when treated in monographs, often with a long list of synonyms. *Scutellaria angustifolia* Pursh of the skullcaps, *Passiflora foetida* L. of the passionflowers, and *Ruellia tuberosa* L. may be cited as examples. If they are treated as polymorphic species their descriptions will be too indefinite or elastic to be of much scientific value. If they are subdivided into a number of "species," based on slight or variable characters, the nomenclature will be cumbersome and the keys difficult to follow; furthermore, the types of the segregated species will have been chosen to represent extremes of variation, and there will remain a number of poorly defined intermediate examples.

In highly variable species of this sort an intermediate course is often practicable. If abundant material is available, it will usually be possible to select suitable characters on which to base a central type as a nucleus, around which may be grouped the closely related forms, mostly as varieties. Often on following such a plan it will be found that these will conform more or less to definite geographic areas. In

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